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EVALUATION OF THE LIMB-BEATING SAMPLING METHOD FOR ESTIMATING SPIDER (ARANEAE) POPULATIONS ON APPLE TREES

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ABSTRACT

The limb-beating sampling method was evaluated with regard to its seasonal efficiency and the effects of the time of day of sampling. The efficiency of limb-beating was generally high throughout the season with averages of 88%, 90%, and 85% for the Salticidae, web-builder (Theridiidae and Dictynidae), and total spiders, respectively. The overall seasonal efficiency of limb-beating for the Thomisidae (includes Philodromidae) was lower (79%) due to the inefficiency in sampling early instar *Philodromus* sp. spiderlings during one sampling date. There were no significant differences ($p > 0.05$) due to time of day of sampling on population estimates obtained for the Salticidae, Thomisidae, web-builders, and total spiders during normal sampling hours of 9:00-18:00. On one of two sampling dates, more nocturnally active clubionids were collected at 3:00 than most other sample periods.

INTRODUCTION

Spiders have been indicated as important predators in Virginia apple orchards (McCaffrey and Horsburgh 1980). However, accurate population assessments are needed to further evaluate their role in the natural control of orchard arthropod pests. The conventional sampling method entails beating tree limbs with a stick over a cloth covered tray; dislodged spiders are then collected (Dondale 1958, Specht and Dondale 1960, Hukusima 1961, Legner and Oatman 1964, Dondale et al. 1979, McCaffrey and Horsburgh 1980). It is generally recognized that this sampling method is inadequate (Putman 1967, Turnbull 1960, 1973), but few studies have indicated to what extent it is deficient or the factors influencing its efficiency. With this in mind, studies were undertaken to determine: 1) the seasonal efficiency of the limb-beating technique for sampling spiders, and 2) the effect of the time of day of sampling on the population estimates obtained using this technique.

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METHODS AND MATERIALS

Seasonal Efficiency of Limb-beating.—This study was conducted in an abandoned apple orchard in Augusta Co., Virginia. The sample unit was the peripheral linear meter of a limb arising from the center of the tree (Lord 1965, 1968). Three limbs from each of eight 'Golden Delicious' apple trees (3-4 m tall) were sampled twice-monthly from May-August, 1977, by the conventional limb-beating method. The limbs were evenly spaced around the tree and 0.5-1.5 m from the ground. Each limb received five sharp taps with a rubber-covered stick over a 1 m^2 muslin covered tray; all spiders dislodged were collected, counted and identified to family. Immediately after being tapped, each limb was enclosed in a 0.88 m x 1.16 m black plastic bag, cut from the tree, and examined in the laboratory for spiders not previously dislodged. The spiders dislodged by limb-beating plus those left on the limbs were considered total capture. All limbs were tapped by the same person to reduce possible sampler variation. Individual limbs were isolated as much as possible to avoid spiders dropping down from surrounding limbs. Only a limited number of trees were available for destructive sampling; therefore, the same trees were used throughout the study. If limb removal affected the integrity of the tree, an adjacent tree was used in its place. Limb-beat and total capture population estimates were compared statistically using paired t-tests.

Effects of Time of Day of Sampling.—This study was conducted in the abandoned orchard mentioned previously. Each sample consisted of those spiders collected by beating the peripheral linear meter of 10 limbs from each of five randomly selected trees of the 'Jonathan' or 'Stayman' variety in a similar manner as described above. Samples were taken at 3 h intervals for a 24 h period 23-24 July and 21-22 August 1977. Again, spiders were identified to family. Analysis of variance and Duncan's Multiple Range Test were used to test for differences among population estimates.

Table 1.—Summary of developmental stages of selected spiders during seasonal sampling evaluation: S = spiderling, A = adult, NR = not represented.

	Spider Stages Represented		
Family, Genus, Species	May-June	July	August
Salticidae			
Eris aurantia (Lucas)	S	S	S,A
Eris marginata (Walckenaer)	S,A	S	S
Hentzia spp.	S,A	S,A	S,A
Metaphidippus galathea (Walckenaer)	S,A	S,A	S,A
Phidippus sp.	NR	NR	S
Thomisidae			
Misumenops asperatus (Hentz)	S	S,A	S,A
Misumenops oblongus (Keyserling)	S,A	S,A	S,A
Misumenoides formosipes (Walckenaer)	S	S	S,A
Philodromus spp.	S,A	S,A	S,A
Xysticus spp.	S,A	S,A	S,A
Theridiidae			
Theridion spp.	S,A	S,A	S,A
Dictynidae			
Dictyna sublata (Hentz)	S,A	S,A	S

RESULTS AND DISCUSSION

Seasonal Efficiency of Limb-beating.–Previous studies have shown that a large complex of spider species inhabits Virginia apple trees (McCaffrey and Horsburgh 1980); this was also evident during this study. A summary of the developmental stages of selected spiders encountered during the seasonal sampling evaluation is presented in Table 1.

The seasonal efficiency (spiders beat from limbs/total capture of spiders) of the limb-beating method for estimating salticid and web-building (Theridiidae and Dictynidae) populations was high with seasonal averages of 88% and 90% respectively. Also, there were no significant differences ($p > 0.05$) between limb-beating and total capture population estimates (Fig. 1). High capture efficiencies for limb-beating were expected for salticids, but not for the web-builders. Putman (1967) indicated these groups (Theridiidae and Dictynidae) to be less efficiently sampled by limb-beating, but he did not state what developmental stages he was sampling. Our observations on the behavior of mid-instar spiderlings and adults showed that when disturbed, the theridiids (*Theridion* spp.) would fold their legs close to their body and drop from their web; the dictynids (*Dictyna sublata* [Hentz]) would run along the leaf on which their web was located and jump off the edge. These behaviors would account for the high efficiencies of capture.

The seasonal efficiency of capture of the Thomisidae was generally high; however, on 12 July fifteen newly hatched *Philodromus* sp. spiderlings were found associated with one limb subsequent to beating. They were still closely associated with the silken egg sack and had not yet dispersed; they reduced the efficiency of capture to 56%. In spite of this low capture efficiency, there were no significant difference ($p > 0.05$) between limb-beat and total capture estimates (Fig. 1).

The category total spiders included representatives of the Salticidae, Thomisidae, Theridiidae, Anyphaenidae, Dictynidae, Clubionidae, Araneidae, and Oxyopidae. Again, the efficiency of limb-beating was high, averaging 85% over the season. However, there were significant differences ($p < 0.05$) noted on 19 May and 12 July between the limb-beating and total capture population estimates (Fig. 1). The overall reduction in efficiency noted on 19 May reflects a cumulative effect of reduced efficiencies for a number of spider groups including the Salticidae and the Thomisidae. The low efficiency on 12

Table 2.–Effect of time of sampling on limb-beating population estimates. Means followed by the same letter in the same column do not differ significantly ($P > 0.05$), Duncan's Multiple Range Test. Philodromids are included in the Thomisidae. Dictynids and theridiids constitute the Web-builder category.

	$\bar{X}$ No. Spiders/Tree									
	Salticidae		Thomisidae		Clubionidae		Web-builders		Total	
Time	23 July	21 Aug	23 July	21 Aug	23 July	21 Aug	23 July	21 Aug	23 July	21 Aug
6:00	3.4 bc	3.4 a	6.4 a	5.2 a	0.6 b	1.0 a	0.5 a	0.6 a	14.6 abc	13.0 a
9:00	4.6 abc	4.4 a	10.4 a	10.0 a	0.4 b	1.0 a	1.1 a	0.7 a	21.6 a	20.4 a
12:00	7.8 a	4.0 a	8.4 a	7.2 a	0.6 b	0.6 a	0.3 a	0.7 a	20.6 a	15.4 a
15:00	5.6 ab	4.6 a	10.4 a	5.8 a	0.6 b	0.8 a	0.4 a	1.0 a	22.0 a	14.8 a
18:00	5.8 ab	3.2 a	7.2 a	4.6 a	1.6 ab	0.3 a	0.6 a	0.5 a	17.8 ab	12.4 a
21:00	1.0 c	2.6 a	4.8 a	3.6 a	0.6 b	0.0 a	0.3 a	0.6 a	8.6 c	9.0 a
24:00	2.2 bc	1.6 a	4.0 a	4.8 a	1.6 ab	0.0 a	0.5 a	0.1 a	9.4 bc	8.6 a
3:00	1.8 c	2.0 a	4.6 a	2.2 a	2.8 a	0.4 a	0.2 a	0.4 a	10.8 bc	7.2 a

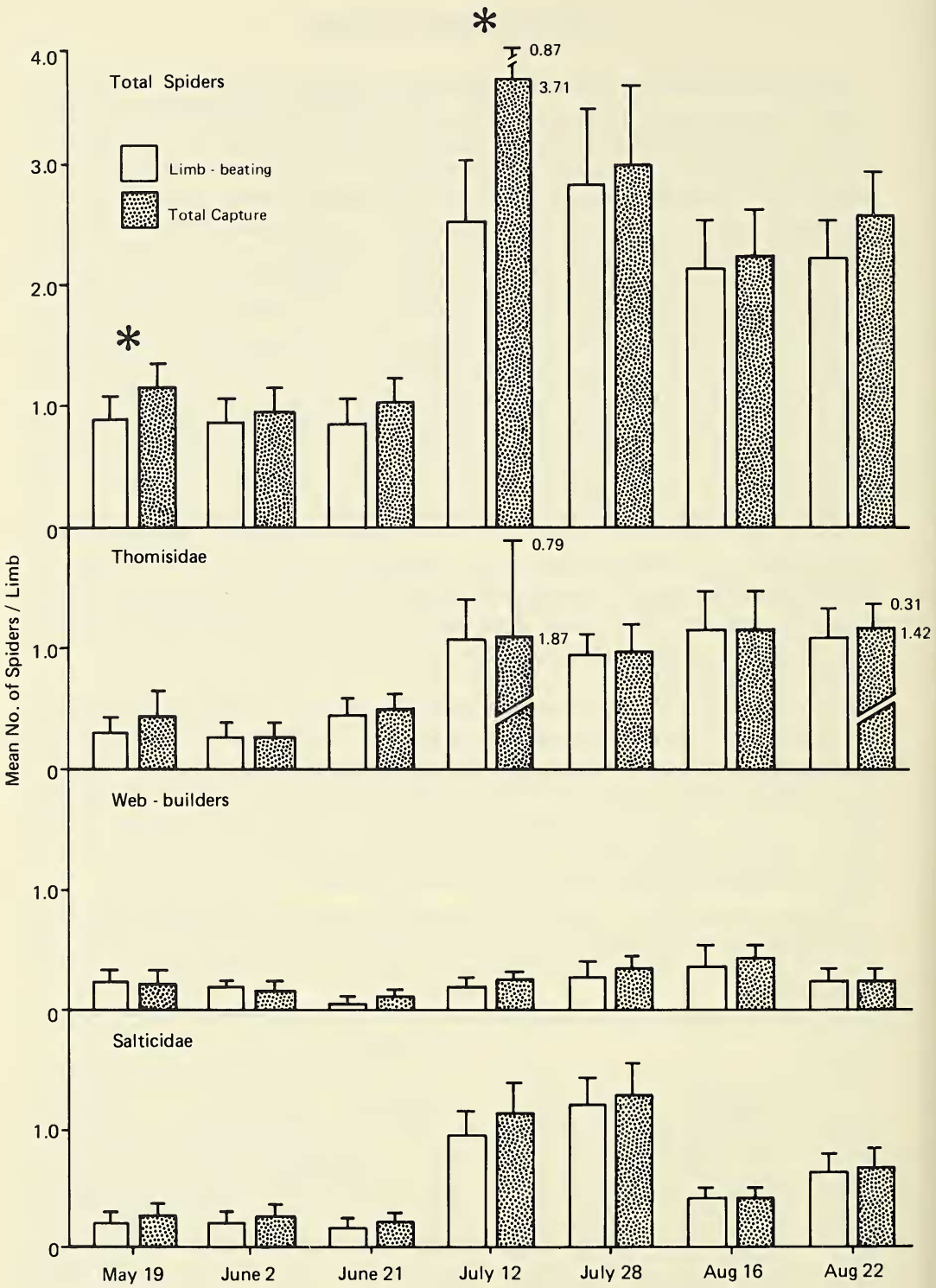

Fig. 1.–Seasonal population estimates of selected spider groups obtained using limb-beating and total capture. An asterick indicates significant differences ($p < 0.05$) between limb-beat and total capture estimates.

July reflects the inefficiency of capturing the *Philodromus* sp. spiderlings and the cumulative small reduction in efficiencies for other families.

Effects of Time of Sampling.–During July, significantly more ($p < 0.05$) salticids and total spider numbers were collected during the daytime sampling hours of 9:00-18:00 than most other sample periods (Table 2). In contrast, significantly more ($p < 0.05$) clubionids (*Clubiona* spp.) were collected at 3:00 than most other sample periods (Table 2). This was expected since the clubionids are represented by many nocturnal species. No significant differences ($p > 0.05$) were found between sampling periods for the thomisids and web-builders during July or for any spider groups in August (Table 2).

The results of this study indicate that the time of sampling by the limb-beat method has little effect on the population estimates obtained during normal sampling times, except for nocturnally active species. This supports Turnbull (1960) who indicated that this sampling method best estimates populations of those spiders active at the time of sampling; resting and hiding places are not effectively sampled.

CONCLUSIONS

The limb-beating sampling method is generally satisfactory for providing quantitative spider population estimates from apple trees. However, consideration must be given for the developmental stage of the spiders being studied; young spiderlings, for example, may not be effectively sampled. Also, the activity periods of the spiders have to be considered. Daytime sampling of nocturnally active species, such as many clubionids may not be satisfactory for estimating populations associated with trees. Finally, in this study, species groups and not individual species are considered. The compensatory actions of one species' behavior to another may have masked any true differences in spider activity and sampling efficiency. Therefore, more detailed studies considering individual species are needed to fully evaluate this sampling method.

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